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PATENT SPECIFICATION (11) 1 537 800

(21) Application No. 38477/77 (22) Filed 15 Sep. 1977 (19)
(31) Convention Application No. 2641879 (32) Filed 17 Sep. 1976 in
(33) Fed. Rep of Germany (DE)
(44) Complete Specification Published 10 Jan. 1979
(51) INT. CL.[2] F16B 4/00 //
F16D 1/06
(52) Index at Acceptance
F2U 244 246
B3V 10

(54) ASSEMBLY COMPRISING MUTUALLY LOCKING COAXIALLY MOUNTED MEMBERS

(71) We, ROBERT BOSCH GMBH, a German Company, of Postfach 50, 7 Stuttgart 1, Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:–

The present invention relates to an assembly comprising mutually locking, co-axially mounted members, such as a shaft and a hub, having mutual engaging surfaces; the members being such that they can be joined together with a relatively small amount of effort but mechanically to lock together to enable them to transmit relatively large forces; the members being required to have a strict tolerance of accuracy in respect of size.

Such an assembly is already known in which the engaging surface of a shaft, being a milled surface, is pressed into a smooth bore in a hub; the bore being the mutual engaging surface of the hub. This type of press-fit is disadvantageous in that the joined members are not usually located coaxially after being fitted, as a result of which they do not rotate accurately relative to a given axis of rotation.

In contrast to this, the assembly in accordance with the invention has the advantage that the members can be interconnected with great accuracy to size, and that the connection can transmit relatively large forces. When the members to be interconnected are a shaft and a hub, they run very accurately relative to one another.

It is particularly advantageous when the material from which at least the engaging surface of the outer member i.e. the member such as hub, is made is harder than the material from which at least the engaging surface of the inner member i.e. the member such as a shaft, is made.

One embodiment of the invention is illustrated in the accompanying drawings, in which:–

Fig. 1 shows a shaft having a pressed-fitted gear wheel;

Fig. 2 shows the shaft without the gear wheel;

Fig. 3 shows the detail III of Fig. 2;

Fig. 4 shows the gear wheel of Fig. 1, drawn to a larger scale;

Fig. 5 shows the detail V of Fig. 4; and

Fig. 6 is a section taken on the line VI–VI of Fig. 4.

Referring to Fig. 1, a gear wheel 2 is pressed fitted onto the end 1 of a shaft. The gear wheel transmits a relatively high torque to the shaft. Fig. 2 shows the shaft 1 without the gear wheel 2, the engaging surface 3, co-operating with a mutual engaging surface 4 of the gear wheel 2 (Figs. 4, 5), being visible. The surface 3 of the shaft 1 (the inner member) has a profile which is formed by adjacent grooves 5 which extend in a circumferential direction and which have a wedge-shaped cross section similar to a screw-thread profile. The grooves 5 are each circular and form, so to speak, a thread having a zero pitch. The external diameter of the surface having the splined or grooved profile 3 is designated $d1^d$ in Fig. 3. The crests of the grooves 5 may rise towards the free end 6 of the shaft 1 within the manufacturing tolerances admissible for the dimension $d1^d$. As may be seen in Fig. 3, the acute angle of the grooves 5, extending in a circumferential direction, is 60 degrees. As is clearly shown in Figs. 2 and 3, the grooves forming the profile of the surface 3 are not provided right up to the free end 6 of the shaft 1. A shoulder 7, whose cross section is equal to the cross section of the shaft 1, is left at the free end 6 of the shaft 1. The cross-sectional dimensions of the shaft 1 (the diameter $d_2{}^d$) correspond to the smallest dimensions of the mutual engaging surface 4 (the diameter $D_2{}^d$) of the gear wheel

2.

The outside of the gear wheel 2 carries spur teeth 8. A chamber 10 (Fig. 6) is provided at that end of the bore in the gear wheel 2 at which the gear wheel 2 is pressed fitted onto the shaft 1 (arrow 11). At the time when the gear wheel 2 is punched, the chamfer may be formed by the punching operation. The surface 4, engaging with the surface 3 of the shaft 1, in the bore of the gear wheel 2 has a profile formed by splined teeth 9 (Figs. 4, 5) extending axially parallel. The splined hub teeth 9 comprise parts forming cylindrical surfaces having the diameter $D1^d$ (the root circle) and cylindrical surfaces having the diameter $D2^d$ (the crown circle) between which are disposed planar flanking surfaces. These cylindrical surfaces may be planar.

As is shown in Fig. 5, the planar flank surfaces are disposed at an angle at 60 degrees relative to one another. When the inner and outer members to be connected, namely, the shaft 1 and the gear wheel 2 respectively, have planar engaging surfaces instead of the above-described cylindrical ones, it will be appreciated that the splined hub teeth 9 are then composed of planar surface elements between which are located the planar flank surfaces.

The external diameter $d1^d$ of the surface 3 of the shaft 1 (the inner member) corresponds to the root circle $D1^d$ of the surface 4 of the gear wheel 2. The crown circle $D2^d$ of the splined hub teeth 9 of the gear wheel 2 (the outer member) corresponds to the diameter $d2^d$ of the guide shoulder 7 of the shaft 1. It will be appreciated that the cross-sectional dimensions $D1^d$, $D2^d$ differ from the cross-sectional dimensions $d1^d$, $d2^d$ by virtue of the admissible manufacturing tolerance. A special advantage of the described assembly is that it can permit relatively large manufacturing tolerances without impairing the quality of the connection. Thus, in accordance with the ISA system of fits, a twelve quality can be permitted for the shaft, and a ten quality can be permitted for the seating 4 of the gear wheel.

For the purpose of joining the two members 1, 2 the crown circle $D1^d$ of the splined hub teeth 9 is first mounted onto the smooth portion of the shaft 1 and an axial pressure is then exerted on the gear wheel 2 in the direction of the arrow 11. During the subsequent pressing together of the two members, the splined hub teeth 9 of the gear wheel 2 which is made from, for example, hardened steel, dig into the grooves 5 of the seating 3 of the shaft 1. The grooves may be produced in a particularly advantageous and simple manner by the thread-rolling method, the shaft 1 being made from a steel which is softer than the material from which the gear wheel 2 is made. The material, which is displaced, to the greater part by the chamfer 10, can enter the regions of the grooves 5 which are located within the diameter $d2^d$. A strong locking connection between the shaft 1 and the gear wheel 2 is thus obtained by the described pressing-fitting operation. Compared with the known pressing-fitting of a milled shaft end into a smooth bore, very accurate running of the gear wheel 2 relative to the shaft 1 is obtained by the arrangement in accordance with the invention. Compared with the similarly satisfactory results with respect to true running obtained by the method of hard-soldering a gear wheel with a smooth cylindrical seating to a shaft having a smooth cylindrical seating, the described arrangement in accordance with the invention is substantially less expensive, since the gear wheel can be hardened as a component member in the bulk material, and the shaft 1 without the gear wheel 2 can be provided with a suitable surface. Since the shaft 1 is joined to the gear wheel 2 by a cold method, stainless steels may be used, this being impossible in the case of, for example, hard-soldering. Furthermore, unintentional thermal treatment, such as soft annealing, of the shaft and the gear wheel 2 during hard-soldering is avoided.

It will be appreciated that the inner member (shaft 1) as well as the outer member (gear wheel 2) can be provided with planar, i.e. non-cylindrical, engaging surfaces. The described pressing-fitting may be effected without the chamfer 10, even though the results are less satisfactory.

WHAT WE CLAIM IS:–

1. An assembly comprising mutually locking, coaxially mounted inner and outer members which are to be joined by axial pressure and which have coaxial mutual engaging surfaces having splined and grooved profiles respectively which are mutually inclined to one another in the longitudinal direction thereof and which are such that the profile of one member digs into the profile of the other member when the two members are fitted together.

2. An assembly according to claim 1, wherein the longitudinal directions of the profiles are normal to one another.

3. Assembly as claimed in claim 1 or 2, wherein the engaging surface of the inner member comprises grooves which extend adjacent to one another in a circumferential direction and which have a wedge-shaped, thread-like cross section, and the mutual engaging surface of the outer member has axially extending splined teeth.

4. An assembly as claimed in claim 3, wherein the wedge shape section of the grooves forms an acute angle of 60 degrees.

5. Arrangement as claimed in claim 4, wherein the threads are circular, that is,

have a zero pitch.

6. Arrangement as claimed in one of the claims 3, 4 or 5, wherein the splined teeth comprise planar or cylindrical surface elements between which are arranged planar flank surfaces forming an angle of 60 degrees relative to one another.

7. An assembly as claimed in claim 3, 4, 5 or 6, wherein the external diameter of the engaging surface of the inner member corresponds to the root circle (D1) of the splined teeth of the outer member.

8. An assembly according to any of the preceding claims, wherein the engaging surface of the outer member has a chamfer at one axial side of the member to facilitate its mounting on the inner member.

9. An assembly according to any of the preceding claims, wherein the inner member at the part first engaging with the outer member on mounting of the two members, is formed with a guide shoulder of a cross-sectional dimension corresponding to the smallest cross-sectional dimension of the engaging surface of the outer member.

10. Arrangement as claimed in any of the preceding claims, wherein the material of at least the engaging surface of the outer member is harder than the material of at least the engaging surface of the inner member.

11. An assembly comprising mutually locking, coaxially mounted inner and outer members, substantially as hereinbefore described with reference to the accompanying drawings.

12. A method of manufacturing an assembly comprising mutually locking, coaxially mounted members having coaxial, mutual engaging surfaces, the method comprising forming the engaging surfaces with splined and grooved profiles respectively, which are mutually inclined to one another in the longitudinal direction thereof, and so that, the profile of one member digs into the profile of the other member when the two members are axially fitted together.

13. A method according to claim 12, wherein the mutual inclination of the profiles is 90°.

14. A method according to claim 12 or 13, substantially as hereinbefore described with particular reference to the accompanying drawings.

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Printed for Her Majesty's Stationery Office, by Croydon Printing Company Limited, Croydon, Surrey, 1978.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

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Fig.3

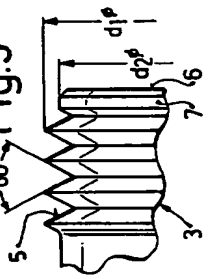

Fig.5

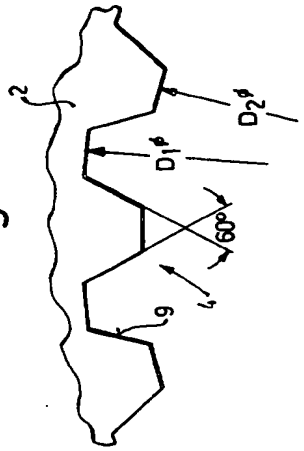

Fig.2

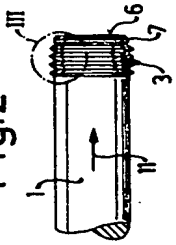

Fig.6

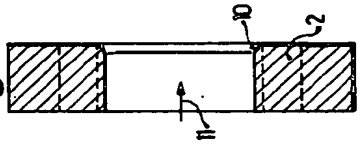

Fig.1

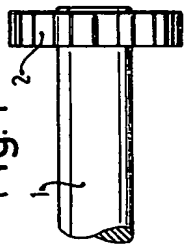

Fig.4

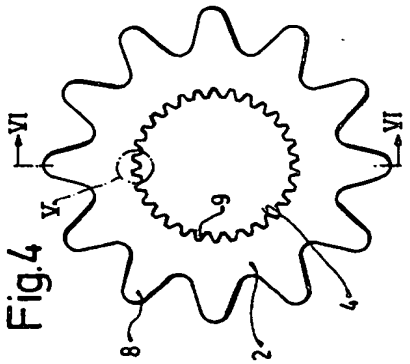

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Fig.3

Fig.5

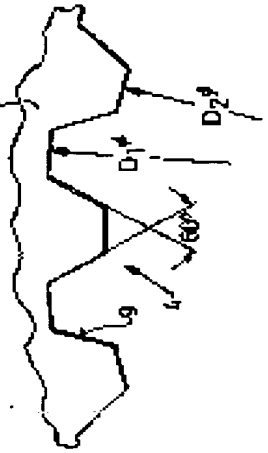

Fig.2

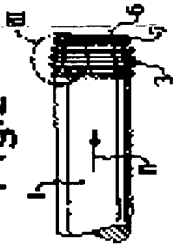

Fig.6

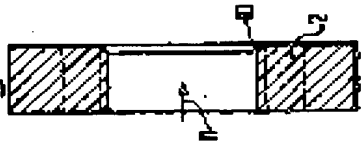

Fig.1

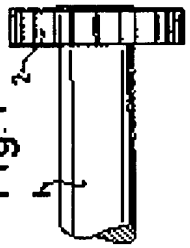

Fig.4